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Equipment Effects on Anhydrous Ammonia Application

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Introduction

Nitrogen fertilizer is a major input in terms of cost and energy into production of corn, wheat, and other nationally important crops such as cotton and rice. Anhydrous ammonia is the most popular form of nitrogen application. In Iowa, 623,000 tons of anhydrous ammonia were applied in 1997 (Terry and Kirby, 1997). In the United States, 4.9 million tons of anhydrous ammonia were applied in both 1996 and 1997. Comparing fertilizer usage by source, anhydrous ammonia supplied 1.0 billion pounds of N (nitrogen) to Iowa cornfields in 1997 while the next most popular source, nitrogen solutions, supplied just 0.5 billion pounds of N. Nationwide, 8.0 billion pounds of N were applied to crops as anhydrous ammonia in both 1996 and 1997. At a cost of $200 to $275/ton of anhydrous ammonia, typical Iowa grower applications of 120 lbs of N per acre on corn result in purchased crop input costs of about $15 to $20 per acre, respectively.

Nitrogen fertilizer application equipment for anhydrous ammonia commonly applies ammonia as a two-phase (liquid and gas) fluid. In a typical system, ammonia travels through the applicator by pressure differential from relatively high pressure in the supply nurse tank to atmospheric pressure at the knife orifice exit. Overall system flow is usually controlled by a variable orifice in the regulator or a heat-exchanger controller. Flow rate through individual distribution lines, however, is thought to be affected by manifold geometry and exit orifice size, distribution hose length, and the outlet through the subsurface injection knife.

Earlier work (Hanna and White, 1998) indicated that distribution from a manifold had more variability across the application swath than did a low-pressure liquid agrichemical sprayer. Manifolds exhibited a trend for the greatest amounts of ammonia to exit from outlets across from the entry point in-line with the initial flow path of ammonia into the manifold. The next greatest amount of ammonia exited outlets on the opposite side of the manifold that may be receiving flow reflected from the initial impact inside the manifold. The least amount of ammonia exited outlets between these points.

Because fluid momentum from liquid ammonia entering the manifold seems to affect flow distribution it may be possible to reduce outlet-to-outlet variation by changing the entry method into the manifold. Allowing ammonia to flow through a straight pipe section immediately before entering the manifold may reduce the tendency for more ammonia to be delivered to some parts of the manifold.

In addition to subdividing flow to multiple ports in a distribution manifold, a pipe tee is often used to split anhydrous ammonia flow on application equipment. Applicators with more than 11 knives often use a pipe tee to split flow to two separate distribution manifolds. The ability of the pipe tee to evenly divide flow is also a distribution concern.

The knife may affect flow rate by its size and number of orifices, as well as tube roughness, shape, and length. Fluid mechanics and continuity-of-flow principals suggest that the rate of ammonia flowing through any distribution line is affected primarily by the most restrictive portion of the flow path. Thus if the manifold or hose is the primary device restricting flow, the knife itself may do little to cause flow variance. Still, in part due to the inability to know exactly what is affecting flow rate, equipment operators are urged to use a set of matched knives.

Objectives

Field experiments were conducted to measure distribution by a conventional manifold with two entry methods, a 25-mm (10-in.) straight pipe and a 90-degree pipe elbow. Also, flow division by a pipe tee during field application was measured. Both distributions were measured at two different flow rates.

A laboratory experiment was set up to determine variation in liquid output of different styles of ammonia knives, the range of output for specific knife styles, and if the average flow rate of specific knife styles were different.

Methods and Materials

Entry and pipe tee experiments

Distribution of ammonia during field application was measured by temporarily re-routing ammonia flow from subsurface injection knives into water containers mounted on an 11-knife toolbar applicator. Ammonia flow from each manifold outlet was measured gravimetrically by the increased weight of the water container. Hose lengths and size to each water container and also to each knife were equal. Specific details of equipment used for field application measurement are described in Hanna and White (1998).

To compare entry methods both an elbow-entry and a straight-entry method were used. For the straight-entry treatment, flow from the regulator was routed through a 25.4-mm (one-inch), 90°-pipe elbow before entering a 254-mm (10-inch) long, 25.4-mm (one-inch) pipe nipple attached above the manifold entry. Regulator height on the applicator was raised for this second treatment so that the manifold and all downstream distribution hoses would be kept at the same elevation. This testing was done at two application rates, 84 and 168 kg N/ha (75 and 150 lb N/a) for each of the two entry methods. Ammonia was collected from 11 outlet ports equally spaced around the perimeter of a 14-outlet conventional manifold (Continental NH_3 3497).

For the experiment to determine how evenly a pipe tee divides flow, plumbing on the applicator was slightly modified. Downstream from the regulator, 25.4-mm (one-inch) pipe and hoses and a 25.4-mm (one-inch) pipe tee were used to divide flow going into two separate conventional manifolds and distribution systems on the left or right sides of the applicator. All hose, manifold, valve, and other plumbing connections were identical in size for both distribution systems. Flow entered the pipe tee through a horizontal, 254-mm (ten-inch) long pipe nipple. The horizontal pipe tee was oriented with exits to the front and the rear. Treatment A consisted of the left manifold distribution system connected to the rear of the tee and right manifold distribution system to the front of the tee. In treatment B, the connections were reversed. Thus each exit side of the tee was alternately connected to each distribution system (left or right). Conventional manifolds used were the same manufacturer and model as used in the manifold entry experiment. Each manifold distributed flow to five knives with unused outlets spaced as evenly as possible around the perimeter of the manifold. Each treatment was replicated three times at two application rates, 84 and 168 kg/ha (75 and 150 lb N/a).

Four measures of variability among outlet distribution were computed. Average outlet difference is the average absolute difference in kg (lb) NH3 of all outlets from the mean outlet output of all outlets for a particular test plot. The average percentage outlet difference is the average of absolute outlet difference from the mean outlet output expressed as a percentage of the mean outlet output. Because slightly different amounts of ammonia were captured at different application rates, this percentage measure is used to indicate the average percentage each outlet is from the mean application rate. Maximum difference is the ratio of the ammonia weight from the outlet with the greatest output to the outlet with the least output for a specific application. Coefficient of variation (standard deviation divided by the mean and expressed as a percentage) among the outlets was also included as this measure is commonly used for low-pressure liquid and granular fertilizer application.

In addition to these measures of distribution variability for all outlet ports of the manifold, it was desired to determine if specific parts of the manifold had greater output than other parts, similar to earlier research (Hanna and White, 1998). To determine this, the manifold was divided into three regions based upon the direction of ammonia flow as it entered the manifold. Outlet ports across from the entry point with incoming flow directed most nearly perpendicularly to them were designated as across from the entry point (across). Outlet ports of each manifold with incoming flow directed most nearly perpendicularly away from them were designated as behind the entry point (behind). Outlet ports most nearly parallel to the incoming flow direction and closest to midway points between these groups were designated as midway. The three regions were equal arcs of 120° around the manifold perimeter (two-60° arcs for the midway region). Regions of the conventional manifold (across, behind, midway) were determined by considering incoming flow before redirection by the pipe elbow.

An equal number of outlets from each region of each manifold (across, behind, midway) were grouped into treatments for further analysis. A statistical analysis of these three groups of outlets was based on a split design with the main treatments consisting of all the combinations of manifold entry (or routing of hoses in the pipe tee experiment) and application rate and the split treatments consisting of the three groups of outlets, across, behind, and midway.

Knife experiment

To obtain a range of different knife styles, three sets of new knives were obtained from fertilizer dealers and a farmer and six sets of used knives were collected from application equipment in south central Iowa. A knife style or set was defined as either visually appearing to be knives of the same design or style or else knives that had been used as a group on a single commercial applicator. Seven additional knife sets and styles were also collected that were present at the Iowa State University Agricultural Engineering Research Center. A summary of the different knife styles tested is given in table one.

To isolate the flow of an individual knife from the influence of a manifold distribution system and/or significant length of hose, only one knife was tested at a time. Because of the safety hazard and difficulty of metering a small ammonia flow to an individual knife and difficulty in providing consistent amounts of gas versus liquid to the knife, liquid water was used as the testing fluid.

A test stand was constructed to supply water at a known pressure to the knife. A centrifugal pump powered by a 0.4 kw (0.5 hp) electric motor supplied water to the knife through a 9.5-mm (3/8-in.) diameter supply hose. A valve on a bypass water line to a water reservoir was adjusted to control water pressure to the knife. Knife water pressure was measured by a pressure gage immediately upstream of the knife. A short length of hose, 0.46 m (18 in.), separated the pressure gage and knife so that knives could be quickly changed by adjusting a hose clamp. During testing, a knife was mounted so that the exit orifice(s) projected water into a 9.5-l (2.5-gal) stainless steel container. A Plexiglas lid was used to prevent water from splashing out of the container during a test. A slot in the Plexiglas permitted the knife to be inserted through it and into the catch container. The container rested on an electronic scale to weigh additions of water. Prior to testing, each knife was cleaned by running a wire back and forth several times through the open tube.

Each knife was tested at four different pressures, 28, 41, 55, and 69 kPa (4, 6, 8, and 10 psi). Pump capacity limited pressure on a few of the knives so that in some cases the highest-pressure measurement was between 55 and 69 kPa (8 and 10 psi). A test of one knife at a specific pressure began by adjusting knife pressure to the desired value. Flow would then be momentarily interrupted while an initial weight of water in the catch container was recorded. Flow was then restarted and continued for 10 seconds at which point flow was stopped. Final water weight in the catch container was recorded. The difference in weights was used to measure flow volume of the knife for 10 seconds at the test pressure.

For each knife, the four flow rates at different pressures were used in a logarithmic transformation to curve-fit the data to a flow versus pressure relationship. Although during field application pressure at the knife is influenced by system pressure, ambient temperature, and application rate, flow rate at 35 kPa (5 psi) was arbitrarily used to compare knives. For those knife-styles with five or greater knives tested, a mean flow rate for that style and 95% confidence interval of the mean was determined using a pooled statistical variance from all the knives tested.

Results and Discussion

Manifold entry method

Results of the experiment to compare variability of manifold outlet distribution due to entry method are shown in table two. It was hypothesized that ammonia flowing through a section of straight pipe immediately before entering the manifold might improve distribution. Ammonia distribution when using the 254-mm (10-inch) long straight entry pipe nipple above the manifold was not statistically different from distribution using the 90°-elbow entry. Although there was a slight trend for better distribution with the straight entry at a 84 kg N/ha (75 lb N/a) application rate, this trend was reversed at the 168 kg/ha (150 lb N/a) application rate. Overall distribution was not improved with the straight entry pipe.

Analyzing data from all 11 ports, there were statistical differences in the amount of ammonia exiting individual outlet port locations around the perimeter of the manifold. In a separate analysis, output data from the 11 ports were divided into three groups of three outlets from each region of the manifold (across, behind, midway) to determine if output was statistically dissimilar. Output from various regions of the manifold was statistically different for both entry methods (table three). The range of flow from these different manifold regions was less when a straight entry was used.

Because of this tendency for varying output from different sections of the manifold perimeter, equipment operators should consider staggering the connection positions of hoses to adjacent shanks on the applicator to different sections on the perimeter of the manifold. For example, the first shank's hose may be attached to an outlet in the "behind" section of the manifold perimeter (behind the entry point with outlet cross-section roughly perpendicular to and away from entry flow). The second shank's hose would be attached to an outlet across from the entry point that is impacted roughly perpendicularly by the entry flow. The third shank's hose would be attached to an outlet in the section midway between these points.

Pipe tee

When ammonia output exiting from manifolds on each side of the 25.4-mm (one-inch) pipe tee was compared to each other, total flow exiting the front and rear of the tee was nearly identical. Averaged across all tests 3.23 kg (7.13 lb) of ammonia exited from the front side of the tee and 3.23 kg (7.12 lb) of ammonia exited from the rear side of the tee. There were no statistical differences in flow exiting either side of the tee regardless of application rate (84 kg or 168 kg N/ha (75 lb or 150 lb N/a)) or which side of the applicator the tee exit (front or rear) was attached to (i.e. left or right manifold). In 12 independent runs made in this experiment, difference in flow between the two exits ranged from 0.5% to 4.6% and averaged 2.4%.

A fewer number of outlet ports, five of the 14, were used on each manifold in this pipe tee experiment. Statistical analysis indicated a difference in the outputs from the five outlet ports. A check was made of outlet port variability from different regions of the manifold by selecting a single outlet from among the five outlet ports that was most nearly across, behind, or midway from the elbow entry point into the manifold. Although the range of output from manifold regions was less for the left manifold, both manifolds had statistically greater ammonia output from ports across from the entry than from midway ports with the plane of the exit-orifice nearly perpendicular to incoming flow (table four).

Knives

Prior to testing, it was noted that several of the knives from one of the new sets (E) had a residual burr from machining at the bottom of the outlet tube. This set was tested both before (EB) and after (E) removing the burrs. During clean out with a wire of the used knives, insect webs, old insect cocoons, and in one case a live insect larva were removed from the fertilizer tube. Orifices on some of the used knives were enlarged due to wear and in a few cases appeared to be two to five times larger than the original orifice. Some fertilizer tubes on used knives were dented in the rear and a few appeared to be bent from use. Inspecting orifices and tubes, knives within an individual set appeared to be all of the same style with the exception of one knife of set F and three knives of set I. Although all knives in set I were removed from a single applicator, close visual inspection indicated that some knives within the set had one rather than two orifices (table 1). A third of the knives in set F had a beaver tail for soil sealing.

For each knife style tested, the number of knives, mean, and coefficient of variation for that knife style are listed in table five. Also listed are the highest and lowest outputs for individual knives within that group and the ratio of these outputs shown as the maximum difference. Mean output at 35 kPa (5 psi) for the 17 knife styles tested ranged from 1.06 to 3.20 kg (2.33 to 7.05 lb) water for 10 seconds. One knife was apparently plugged and did not produce any water flow at pressures of up to 69 kPa (10 psi). Excluding this knife, output of individual knives ranged from 0.73 to 3.36 kg (1.62 to 7.40 lb) water. Although two sets of new knives (O and D) had the lowest coefficients of variation, two other new sets (E and EB) had coefficients of variation greater than several used sets. Within a given knife style it was not uncommon that flow rate from one knife would be 1.5 to 2 times the flow rate from another knife. Within a set, output variation ranged ten percent or less for two of the new knife sets (D and O), however output varied 129 and 93%, respectively for new sets E and EB. The coefficient of variation of used set I (actually composed of three different types of knives) tended to be near the midrange of that of the other used sets. This indicates that although there is probably an advantage to matching used knife sets, wear over time may cause additional variability. In particular, the orifices of set G appeared to have the greatest wear and had the greatest coefficient of variation for sets with five or more knives.

Among individual knife sets, set K was a new and used knife of the same manufacturer/model. Greater output was obtained from the new knife. Knives of set J were the same manufacturer/model as set K, however they were all used and in place of a vapor tube, a dry fertilizer tube was attached to the ammonia tube.

For the eleven knife styles in which five or more knives were available for testing, statistical confidence intervals were determined using the pooled variance for all knives tested. The lower and upper limits listed in table six represent the lowest and highest outputs expected from that group of knives 95% of the time. All four sets of new knives had distinctly different flow rates, decreasing in the order of O, D, E, and EB. New style EB had lower output than most other styles. Although there was considerable variability in knife set E after deburring (c.v. = 22.7%, table five) output clearly was increased following removal of burrs from this set. After burr removal, style E had output flow similar to most of the used styles. Output from used knives generally fell into two classes with knife styles A, B, and I having output greater than from styles C, F, G, and J. New style D had output flow similar to used styles A, B, and I.

Considering the new knife sets, flow rate uniformity was better for styles D and O than styles E and EB. Unless specified by the manufacturer, flow rate uniformity cannot be determined by the operator until after knives have been tested. Anhydrous ammonia knives have other important features such as fertilizer release point, soil disturbance and sealing, and resistance to wear. Knife style E/EB had a narrower profile than other new knives and may have different soil disturbance and soil sealing characteristics.

Because water was used for testing flow rates rather than anhydrous ammonia, it is not possible to directly predict the rate and variability of ammonia output of the knives from these data. Ammonia output would be a mixture of liquid and gas. Although water flow rates for 10 seconds typically ranged from one to three kilograms (two to seven pounds), typical ammonia flow rates through a knife for 10 seconds are only about one-tenth this amount by weight, 0.06 kg (0.38 m knife spacing, 56 kg N/ha, 8 km/hr; or 0.13 lb for 15 in. knife spacing, 50 lb N/acre, 5 mi/hr) to 0.35 kg (0.76 m knife spacing, 168 kg N/ha, 8 km/hr; or 0.77 lb for 30 in. knife spacing, 150 lb N/acre, 5 mi/hr). Most of the volume of ammonia exiting the knife may be predominantly gaseous, however, and correspond to the observed range of 0.8 to 3.8 l (0.2 to 1.0 gal) of water flowing out the knife in 10 seconds.

Perhaps more importantly, flow through individual distribution lines may be affected more by division at the distribution manifold or friction losses through distribution hoses and fittings than by restriction at the knife. In particular a knife style which least restricts flow such as style O may be advantageous as it would have the least effect on ammonia flowing through the distribution line.

Conclusions

Using a straight-entry pipe, ten pipe-diameters long, attached above a conventional manifold does not improve distribution over that of a 90°-elbow pipe entry at application rates of 84 and 168 kg N/ha (75 and 150 lb N/a). Because of the tendency for different rates of flow from different regions, it is recommended that distribution hoses to adjacent shanks be attached to different regions of the manifold (i. e. across from the entry point, behind the entry point, and midway between these points).

A 25.4-mm (one-inch) pipe tee divides flow rather evenly when supplying ammonia to two identical manifold delivery systems. The pipe tee tested was oriented horizontally with a 254-mm (10-inch) straight-entry pipe. Average flow difference between exits of the pipe tee was 2.4% in twelve trials at two application rates.

Regarding knives, within the range of water flow rates used in tests, the following conclusions can be made. Different new knife styles have different flow rates. To be prudent, it is recommended that knives, particularly new ones, be carefully matched on the applicator. Although some new knife styles tested had lower flow rate variability than used knife styles, other new styles had variability similar to used knife styles.

Obstructions such as burrs left from machining operations in new fertilizer tubes lower flow rates. Dents in fertilizer tubes of used knives are common. Dents are usually on the rear half of tubes and may be caused by impact as mounting holes are positioned or the applicator is turned or backed. One used knife removed from a field applicator delivered no flow at pressures up to 10 psi. The set including this knife had orifices that appeared visually very worn and had a high coefficient of variation. Insect webbing, used cocoons, and in one case a live larva were found inside fertilizer tubes on knives removed from applicators.

Recommendations for knives

1. Carefully match knives on the applicator. New knives in particular may have distinctly different flow rates for different styles.
2. Inspect used knives for visual dents and kinks in the fertilizer tube that may restrict flow. Be careful when mounting knives or turning or backing the applicator so fertilizer tubes are not impacted and damaged. Manufacturers may want to consider adding some protection for tubes on the rear of knives.
3. Clean knives periodically, particularly at the beginning of a season. If the applicator has been unused for some period of time, rust, insect cocoons, or other foreign material may restrict flow.
4. Inspect new knives and remove machine burrs that may restrict flow.
5. Although some new knife styles have less variability than used knives, some do not. In other words, although new knives may lessen variability, there is no guarantee of this.

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Table 1. Anhydrous ammonia knives tested

Knife style	New or used	No. of orifices	Bends in tube	Heel?[*]	Vapor tube?[†]	Beaver tail?[‡]	Additional notes
A	Used	1		Yes	Yes		
B	Used	2					Center mount
C	Used	2	2				Center mount, long tube
D	New	1		Yes			
E	New	1					Extra thin design
EB	New	1					Knife "E" before deburring
F	Used	2				3 of 9	Flattened tubes, F4 was different knife
G	Used	2				Yes	Worn tubes, very used
H	New	2		Yes		Yes	Narrowly open at bottom of heel
I	Used	2 (1)				Yes	Mixed set, mostly two orifice[§]
J	Used	1		Yes		Yes	With dry fertilizer tube
K	Both	1		Yes	Yes	Yes	
L	Used	2	1				Very used, bend at bottom
M	Used	1					Rear orifice exit
N	Used	1			Yes		Cold-flo knife
O	New	2					
P	Used	1		Yes		Yes	

[*]Heel is small square attached at bottom of fertilizer tube.

[†]Vapor tube is secondary fertilizer tube for ammonia vapor.

[‡]Beaver tail is flat section shaped like a beaver's tail and attached to knife above fertilizer outlet. It is used to help seal soil.

[§]Mixed set; knives 1, 5, 6, 7, 8, 9 were different part no. than knives 2 and 4 which were different from knife 3.

Table 2. Anhydrous ammonia output variability from shank-to-shank on an 11-knife applicator.

Treatment	Avg. outlet difference, NH_3*		Avg. % outlet difference†	Maximum difference‡	Coefficient of variation, %
	kg	lb			
84 kg/ha (75 lb/a)					
Elbow entry	0.127	0.281	19.6	2.16	25.3
Straight entry	0.107	0.235	18.0	2.20	24.7
168 kg/ha (150 lb/a)					
Elbow entry	0.054	0.118	10.2	1.62	13.5
Straight entry	0.078	0.171	12.8	1.63	15.9

*Average kg (lb) NH3 difference of an outlet from mean of outlets
†Average difference of outlet from mean of outlets expressed as a percentage of mean
‡Maximum difference = maximum outlet weight/minimum outlet weight

Table 3. Anhydrous ammonia output per outlet from different regions of the manifold (11-ports, entry experiment).*

	Outlet location from entry point into manifold					
Treatment	Behind		Midway		Across	
	kg	lb	kg	lb	kg	lb
Elbow entry	0.531b	1.17b	0.513b	1.13b	0.730a	1.61a
Straight entry	0.653a	1.44a	0.517b	1.14b	0.662a	1.46a

*Values in each row followed by a different letter are significant at the $\alpha = 0.05$ level

Table 4. Anhydrous ammonia output per outlet from different regions of the manifold (5-ports, tee experiment).*

	Outlet location from entry point into manifold					
Treatment	Behind		Midway		Across	
	kg	lb	kg	lb	kg	lb
Left manifold	0.640a	1.41a	0.612b	1.35b	0.640a	1.41a
Right manifold	0.553b	1.22b	0.553b	1.22b	0.771a	1.70a

*Average of 84 and 168 kg/ha (75 and 150 lb/a) application rates with tee outlets alternately attached to manifolds on the left and right sides of the applicator. Values in each row followed by a different letter are significant at the $\alpha = 0.05$ level

Table 5. Water output at 35 kPa (5 psi) for various styles of anhydrous ammonia knives

Knife style	No. of knives	Mean, kg/10 sec	Mean, lb/10 sec	Coefficient of Variation, %	High, kg/10 sec	High, lb/10 sec	Low, kg/10 sec	Low, lb/10 sec	Maximum difference
A	5	2.28	5.03	15.0	2.52	5.56	1.69	3.72	1.49
B	5	2.07	4.57	7.5	2.26	4.98	1.86	4.11	1.21
C	7	1.51	3.33	23.1	1.98	4.36	0.89	1.96	2.22
D	9	2.34	5.16	3.0	2.46	5.42	2.24	4.94	1.10
E	9	1.85	4.07	22.7	2.15	4.74	0.94	2.07	2.29
EB	9	1.10	2.42	23.1	1.44	3.17	0.74	1.64	1.93
F	9	1.45	3.20	15.1	1.79	3.95	1.17	2.57	1.53
G	8	1.27	2.81	54.2	1.88	4.15	0.00	0.00	-----
H	4	1.88	4.14	9.7	2.13	4.69	1.70	3.75	1.25
I	9	1.90	4.18	13.9	2.30	5.07	1.37	3.02	1.68
J	6	1.50	3.31	9.3	1.68	3.70	1.32	2.90	1.27
K	2	1.61	3.56	15.5	1.79	3.95	1.44	3.17	1.25
L	1	1.06	2.33						
M	1	2.34	5.15						
N	1	3.12	6.88						
O	9	3.20	7.05	2.4	3.36	7.40	3.10	6.84	1.08
P	2	1.35	2.97	64.4	1.96	4.32	0.73	1.62	2.67

Table 6. 95% confidence interval for water output , kg/10 sec (lb/10 sec), at 35 kPa (5 psi) of various styles of anhydrous ammonia knife

		kg/10 sec			lb/10 sec		
			95% Confidence Interval			95% Confidence Interval	
Knife style	No. of knives	Mean	Lower limit	Upper limit	Mean	Lower limit	Upper limit
A	5	2.28	1.99	2.58	5.03	4.38	5.68
B	5	2.07	1.78	2.37	4.57	3.92	5.22
C	7	1.51	1.26	1.76	3.33	2.78	3.88
D	9	2.34	2.12	2.56	5.16	4.67	5.64
E	9	1.85	1.62	2.06	4.07	3.58	4.55
EB	9	1.10	0.88	1.32	2.42	1.94	2.91
F	9	1.45	1.23	1.67	3.20	2.71	3.68
G	8	1.27	1.04	1.51	2.81	2.29	3.32
I	9	1.90	1.68	2.12	4.18	3.70	4.67
J	6	1.50	1.23	1.77	3.31	2.72	3.90
O	9	3.20	2.98	3.42	7.05	6.56	7.53

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